


# A Python astronomy package for HiPS: Hierarchical Progressive Surveys

Adeel Ahmad<sup>1</sup>, Christoph Deil<sup>2</sup>, Thomas Boch<sup>3</sup>, Brigitta M Sipőcz<sup>4</sup>,  
and Axel Donath<sup>2</sup>

<sup>1</sup> National University of Computer and Emerging Sciences, Islamabad, Pakistan <sup>2</sup> Max Planck Institute for Nuclear Physics, Heidelberg, Germany <sup>3</sup> Université de Strasbourg, CNRS, Observatoire astronomique de Strasbourg <sup>4</sup> Institute of Astronomy, University of Cambridge, Madingley Road, Cambridge, CB3 0HA, UK

DOI: [00.00000/joss.00000](https://doi.org/10.00000/joss.00000)

## Software

- [Review](#) 
- [Repository](#) 
- [Archive](#) 

Submitted: 00 January 0000

Published: 00 January 0000

## License

Authors of papers retain copyright and release the work under a Creative Commons Attribution 4.0 International License ([CC-BY](#)).

## Summary

HiPS (Hierarchical Progressive Surveys) (Fernique et al. 2015) is built upon the HEALPix framework (Górski et al. 2005) and provides a way to store large astronomical survey sky images and catalog datasets on servers (such as HiPS at CDS (<http://aladin.u-strasbg.fr/hips>), that allows clients to efficiently fetch only the image tiles or catalog parts for a given region of the sky they are interested in.

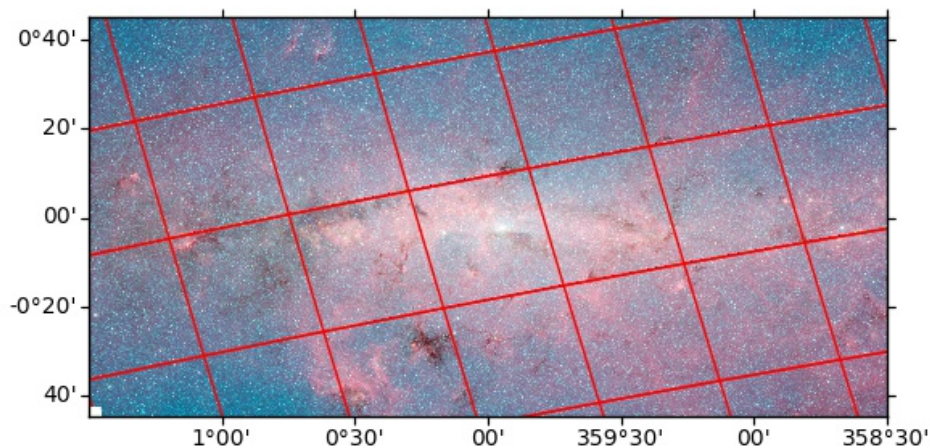
Currently, there are clients built using HiPS, such as Aladin Desktop (<http://aladin.unistra.fr/AladinDesktop>) and Aladin Lite (<http://aladin.unistra.fr/AladinLite>) but they are written in Java and JavaScript, respectively. There is also `ipyaladin` (<https://github.com/cds-astro/ipyaladin>), which provides a bridge between Jupyter and Aladin Lite, and enables interactive sky visualization in IPython notebooks.

## Scope of the Package

The `hips` Python package supports version 3.6 or later and runs on most Operating Systems including Linux, Windows, and macOS. It provides flexibility by extending both a high-level and low-level API for novice and advanced users, respectively. It provides the functionality for drawing a sky image from HiPS tiles, transforming HiPS to WCS images, and HEALPix to HiPS—which takes in HEALPix data stored in the “nested” scheme and creates a dictionary object containing HiPS. Additional features include progress bar reporting (`tqdm` <https://github.com/tqdm/tqdm>), asynchronous tile fetching (`aiohttp` <https://github.com/aio-libs/aiohttp>), image input / output (`pillow` <https://python-pillow.org>), and support for multiple image formats including FITS, PNG, and JPG. The FITS format stores image metadata in a human-readable ASCII header and is the standard for astronomical applications. Whereas, PNG and JPG formats contain RGB color images.

The modules provided by this package mostly build upon Astropy (The Astropy Collaboration et al. 2018) affiliated packages, namely, `astropy-healpix` (<https://github.com/astropy/astropy-healpix>) and `reproject` (<https://reproject.readthedocs.io>). The drawing module makes extensive use of projective transformation for which we acknowledge `skimage` (Walt et al. 2014).

For a more comprehensive introduction to the `hips` package, please see the documentation at (<http://hips.readthedocs.io>) and the source code at (<http://github.com/hips/hips>).



**Figure 1:** Astronomical sky image made with the hips Python package using IPAC/P/GLIMPSE360 HiPS survey

## Tile Drawing Algorithm

Projective transformation is applied for projecting HiPS tiles onto the sky image. To achieve this, we first compute the tile corners, which helps us in determining the position where the tile is to be placed. The tiles are further split into four children tiles, which is done to fix the tile distortion issue, and results in a more precise image.

## Acknowledgements

This project was initiated as part of Google Summer of Code 2017 program (<https://summerofcode.withgoogle.com>) under the Open Astronomy umbrella organization during which period v0.1 and v0.2 were released. The release of v0.3 is expected in summer 2018. The authors would like to thank Google for hosting this program.

## References

- Fernique, P., M. G. Allen, T. Boch, A. Oberto, F.-X. Pineau, D. Durand, C. Bot, et al. 2015. “Hierarchical progressive surveys. Multi-resolution HEALPix data structures for astronomical images, catalogues, and 3-dimensional data cubes” 578 (June): A114. <https://doi.org/10.1051/0004-6361/201526075>.
- Górski, K. M., E. Hivon, A. J. Banday, B. D. Wandelt, F. K. Hansen, M. Reinecke, and M. Bartelmann. 2005. “HEALPix: A Framework for High-Resolution Discretization and

Fast Analysis of Data Distributed on the Sphere” 622 (April): 759–71. <https://doi.org/10.1086/427976>.

The Astropy Collaboration, A. M. Price-Whelan, B. M. Sipőcz, H. M. Günther, P. L. Lim, S. M. Crawford, S. Conseil, et al. 2018. “The Astropy Project: Building an inclusive, open-science project and status of the v2.0 core package.” *ArXiv E-Prints*, January.

Walt, Stéfan van der, Johannes L. Schönberger, Juan Nunez-Iglesias, François Boulogne, Joshua D. Warner, Neil Yager, Emmanuelle Gouillart, Tony Yu, and the scikit-image contributors. 2014. “Scikit-Image: Image Processing in Python.” *PeerJ* 2 (June): e453. <https://doi.org/10.7717/peerj.453>.